Linear & Non-Linear X-Ray Interaction with Materials

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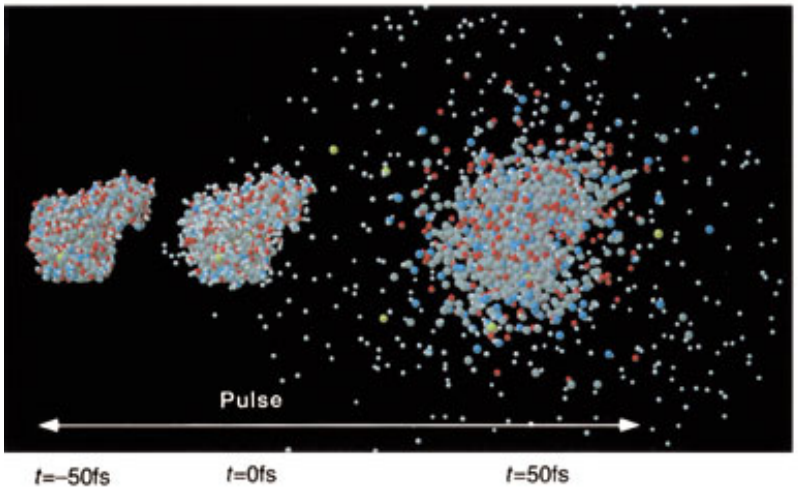
Science @ LCLS

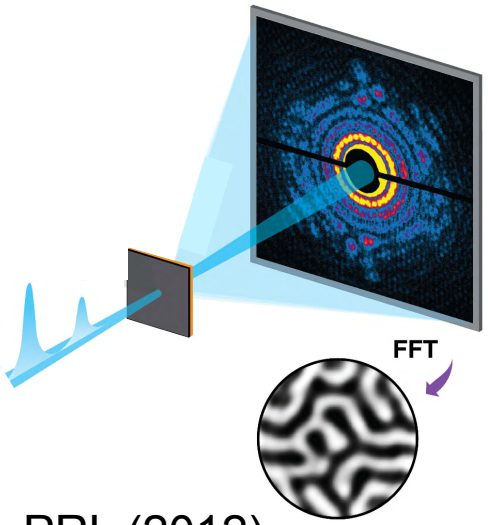
present: 10^{13} photons/pulse @ 120 Hz

pump before destroy in biology



Neutze et al, Nature (2000)

single-shot magnetic holography



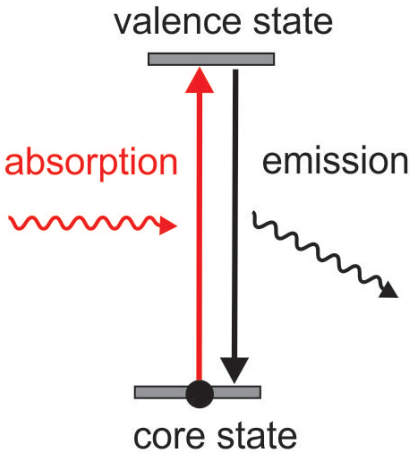
Wang et al, PRL (2012)

future: 10^{13} photons/pulse @ 1 MHz

Linear & non-linear x-ray interaction with materials

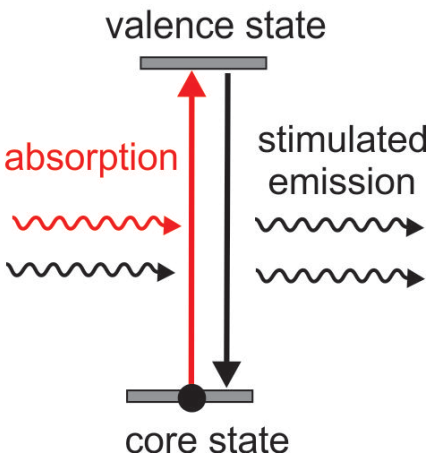
element specific
electronic (x-ray energy) &
magnetic (polarization)
structure sensitive

Resonant scattering



one photon at a time

Stimulated resonant scattering



multi-photon regime

Linear & non-linear x-ray interaction with materials

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electronic (x-ray energy) &
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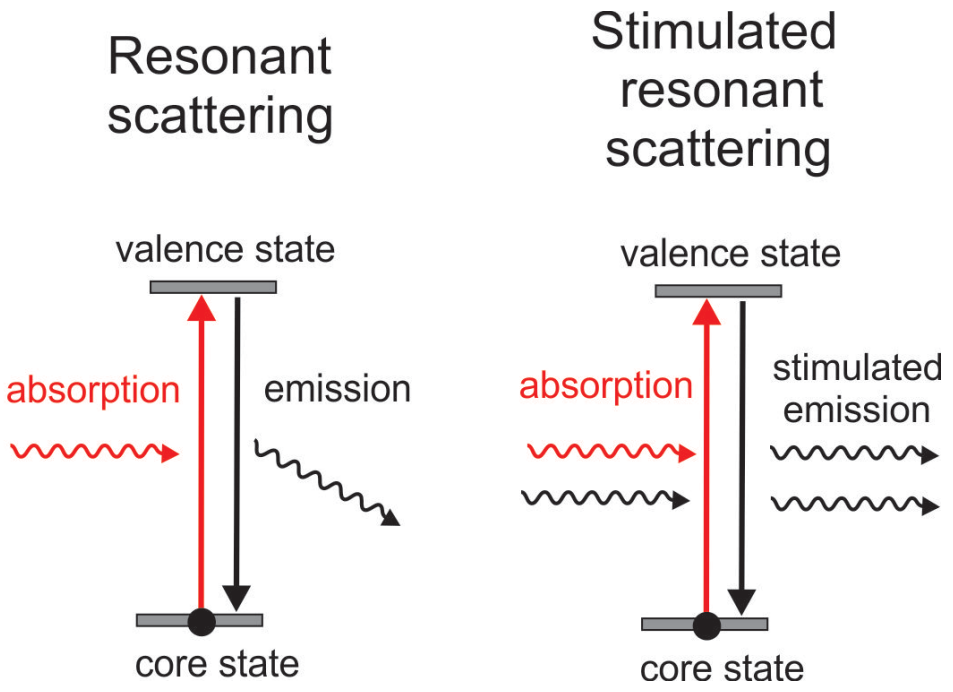
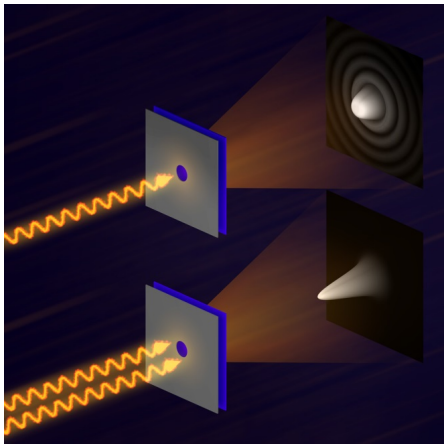
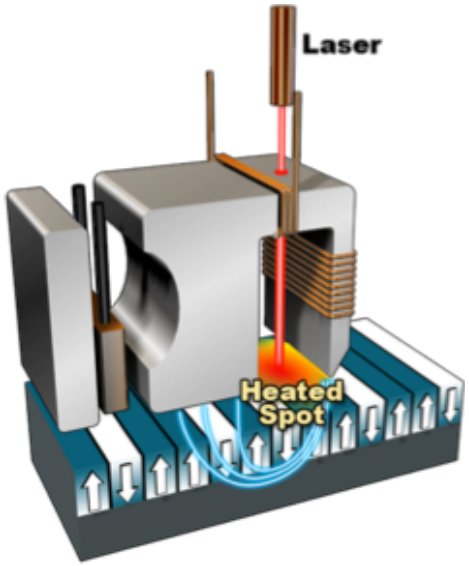


holography, CDI

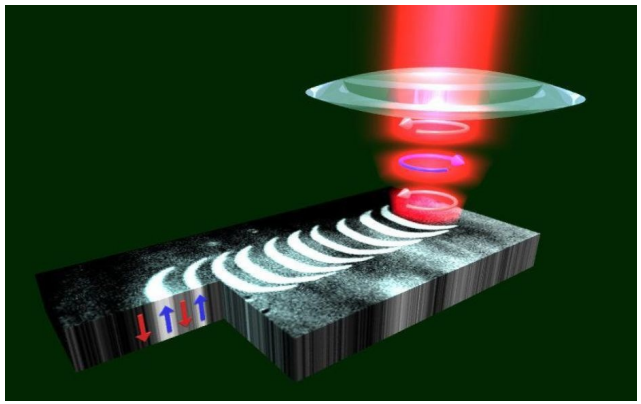


Towards single-shot x-ray holography snapshots of all-optical recording below the diffraction limit

Near-field antennas are already used for Heat Assisted Magnetic Recording

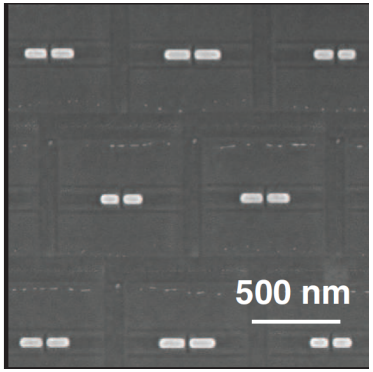


can we use plasmonic Au nano antennas for all-optical switching?

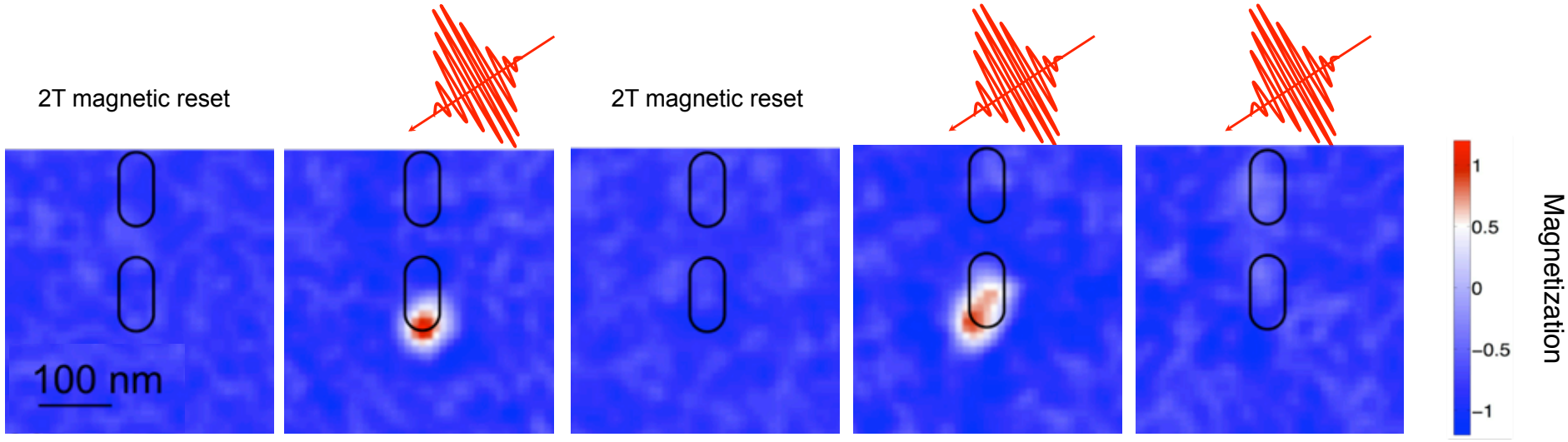


Stanciu, et al PRL (2007)

Magnetic switching back and forth in FeCoTb

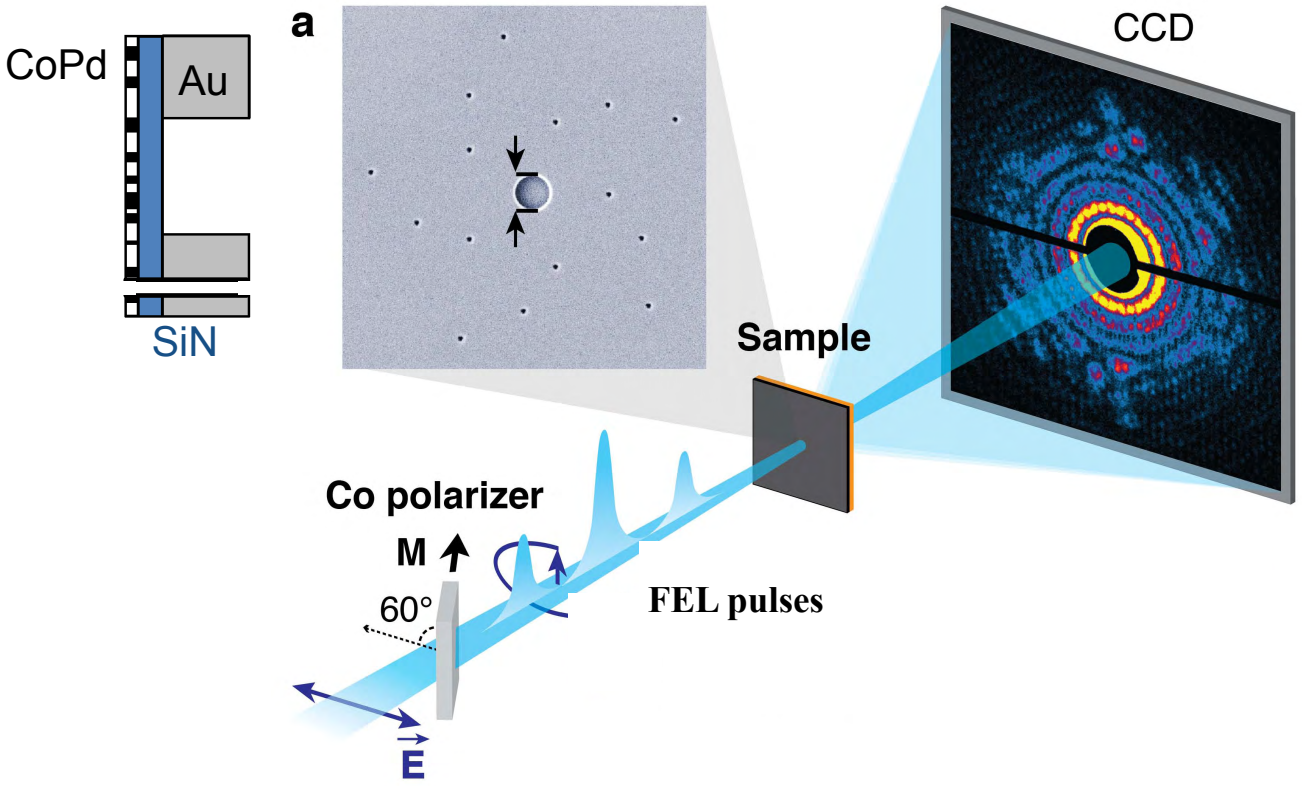


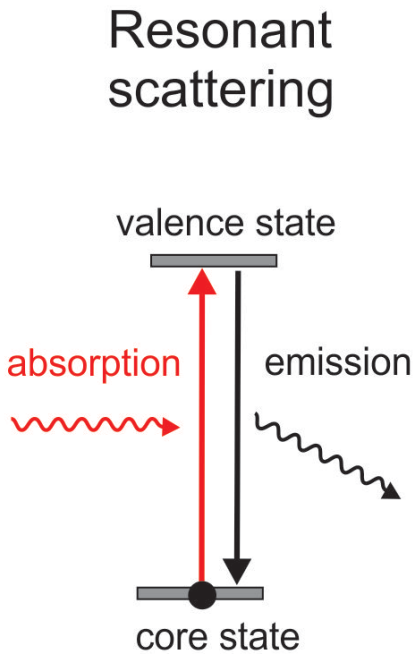
Focus on one antenna



T. Liu, et al. Nano Lett. **15**, 6862 (2015)

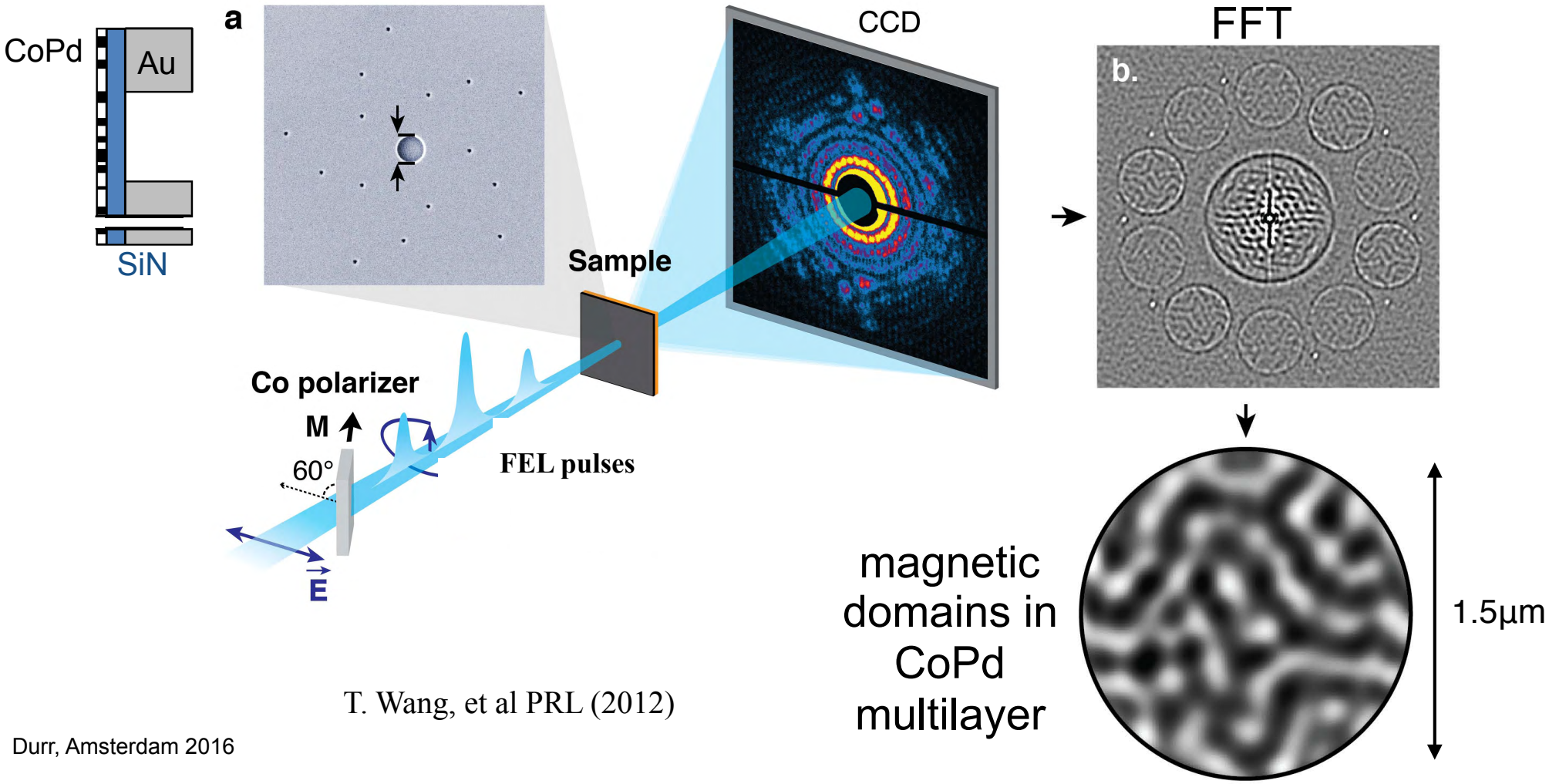
Single shot imaging of magnetic domains





T. Wang, et al PRL (2012)

Single shot imaging of magnetic domains is possible



T. Wang, et al PRL (2012)

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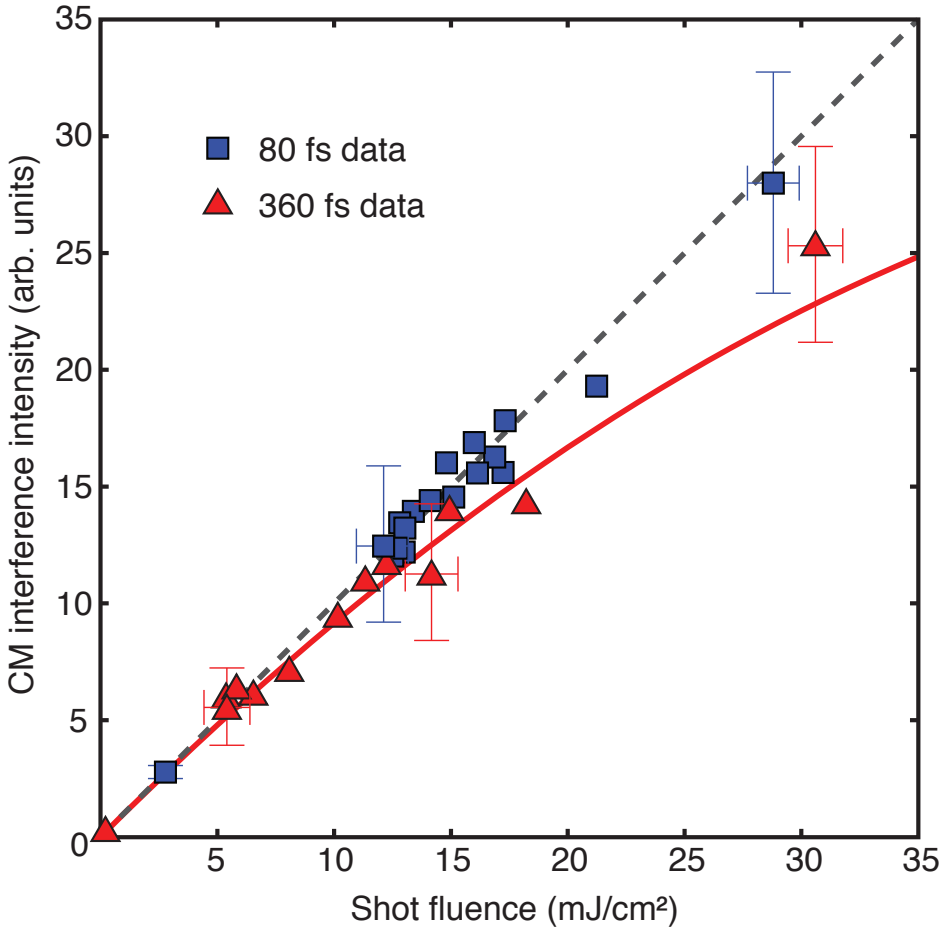
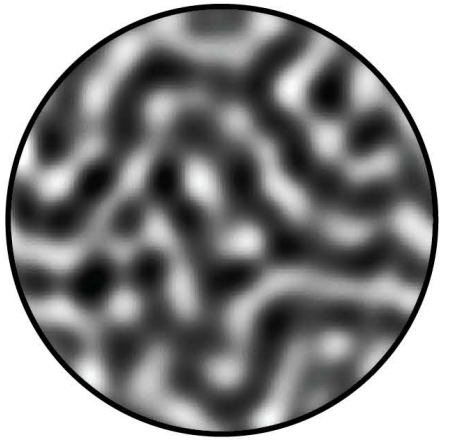


T. Wang, et al PRL (2012)

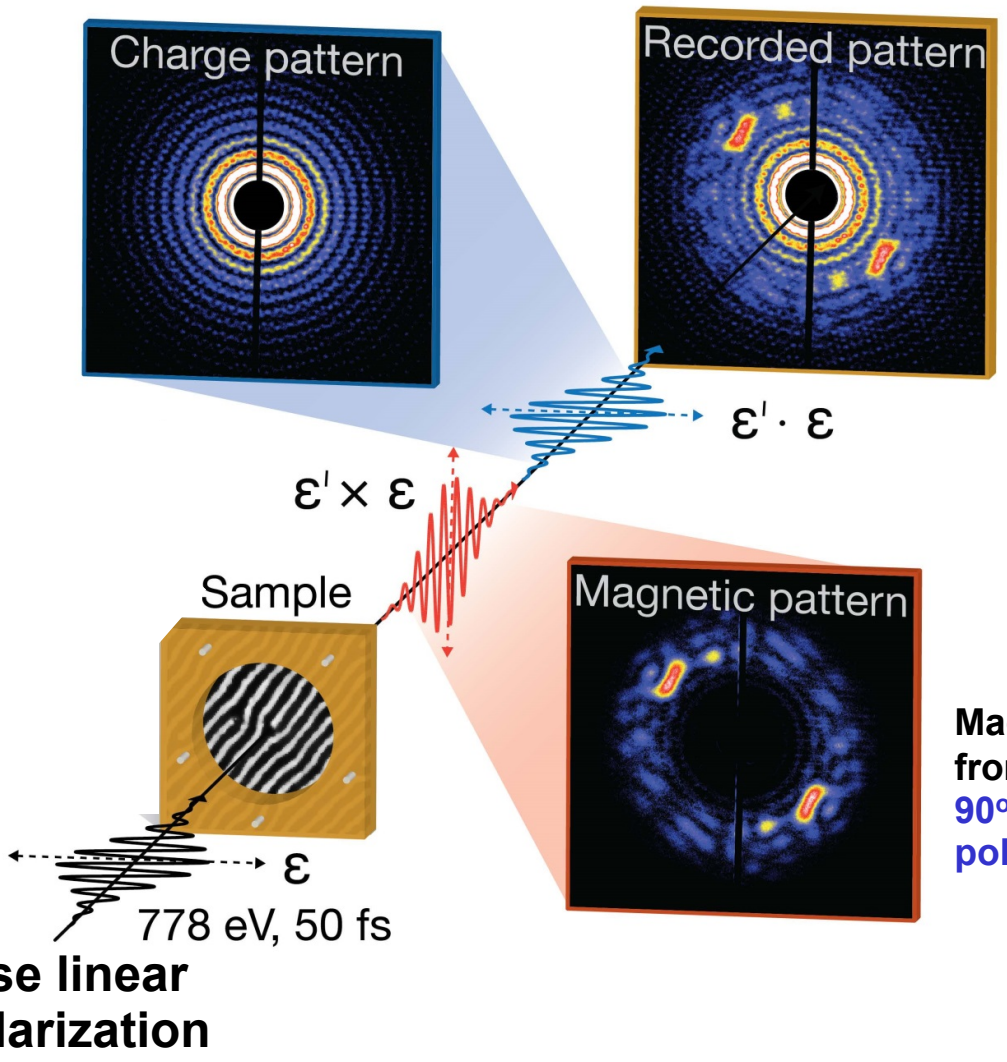
With short pulses we can outrun x-ray-induced magnetic 'damage' (demagnetization)

magnetic domains in CoPd multilayer



But at very high x-ray fluence something surprising happens

Charge pattern comes from circular aperture: no polarization change



Magnetic pattern comes from dichroism effect 90° rotation of linear polarization:

B. Wu et al, Phys.Rev. Lett. **117**, 027401 (2016)

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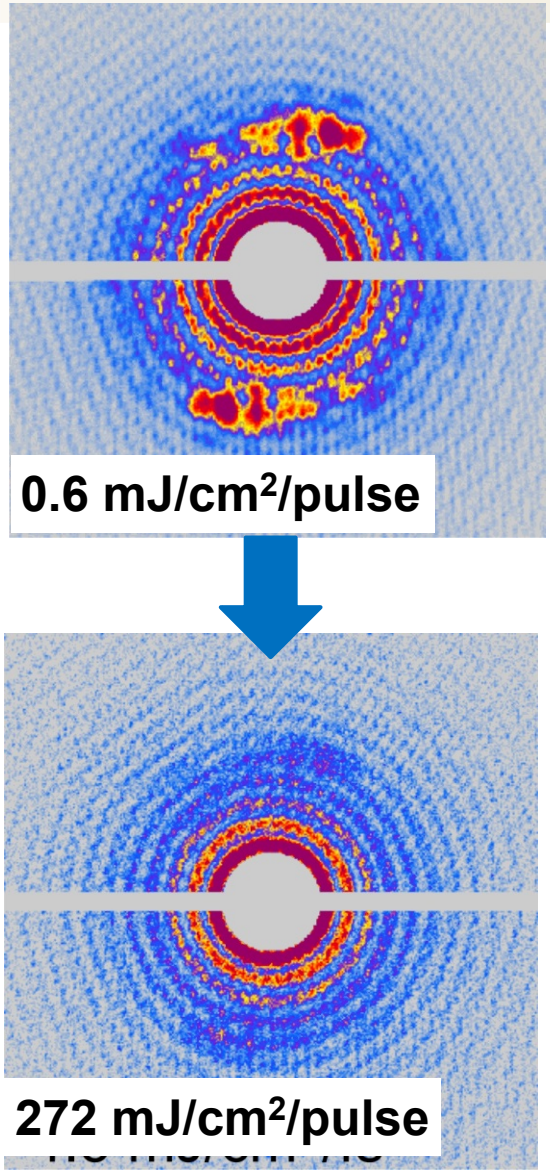
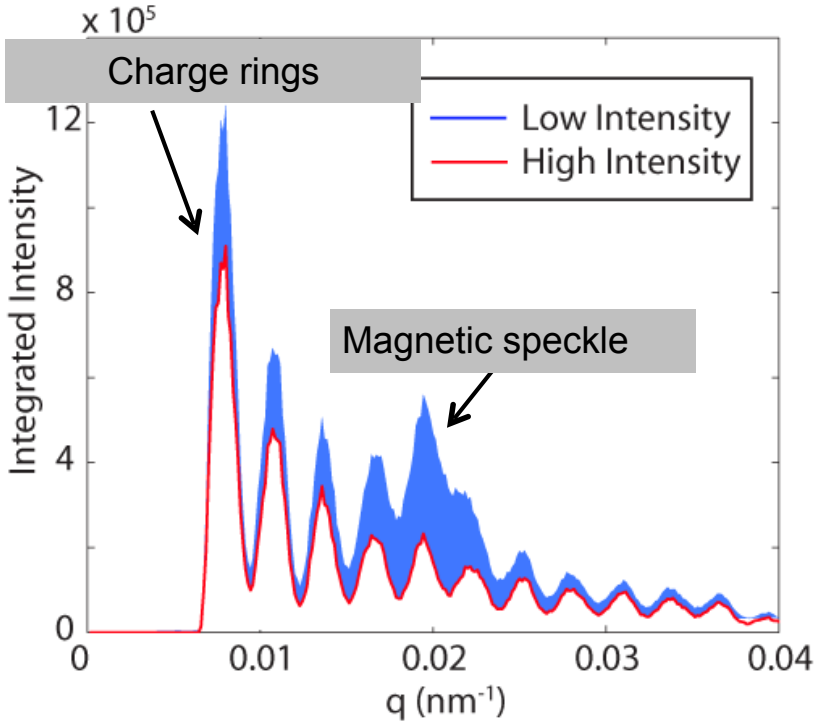


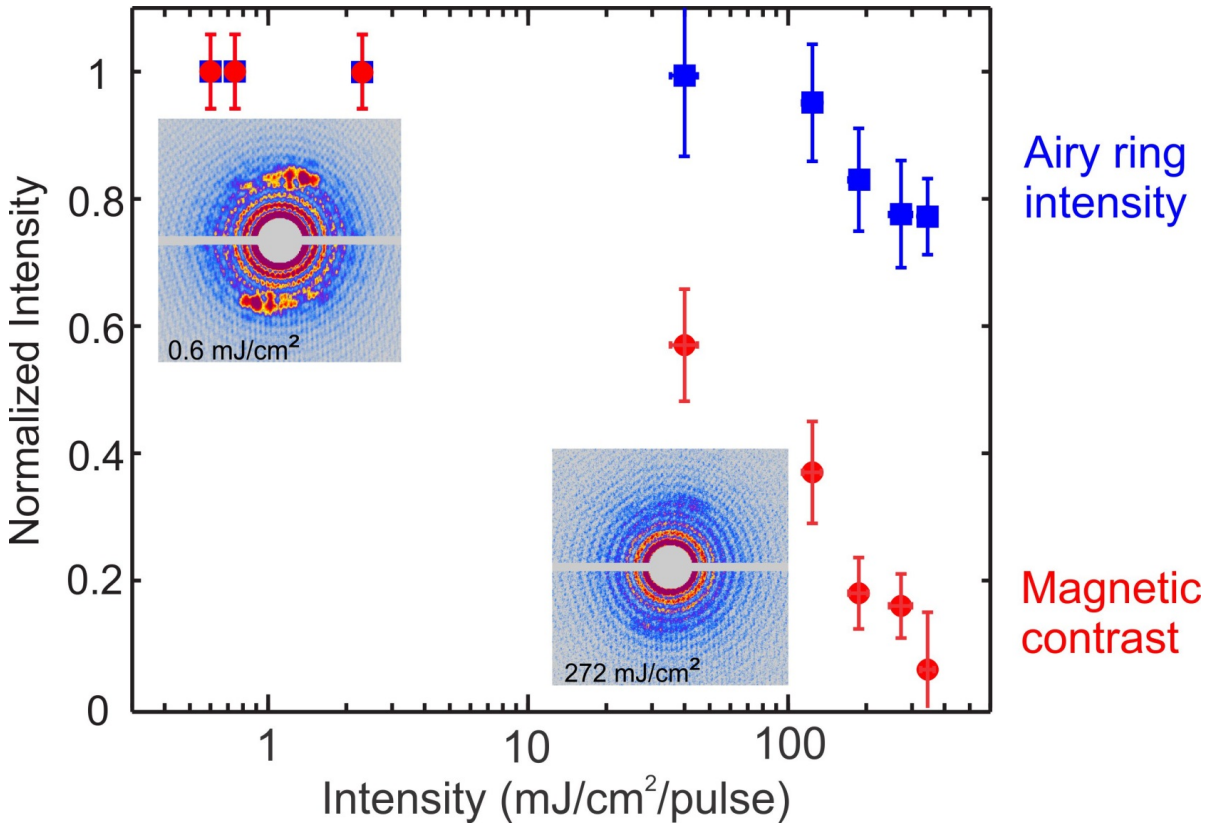
Intensity versus q



- Magnetic speckle pattern disppears with increased LCLS pulse intensity
- Airy ring pattern intensity from circular aperture also decreases

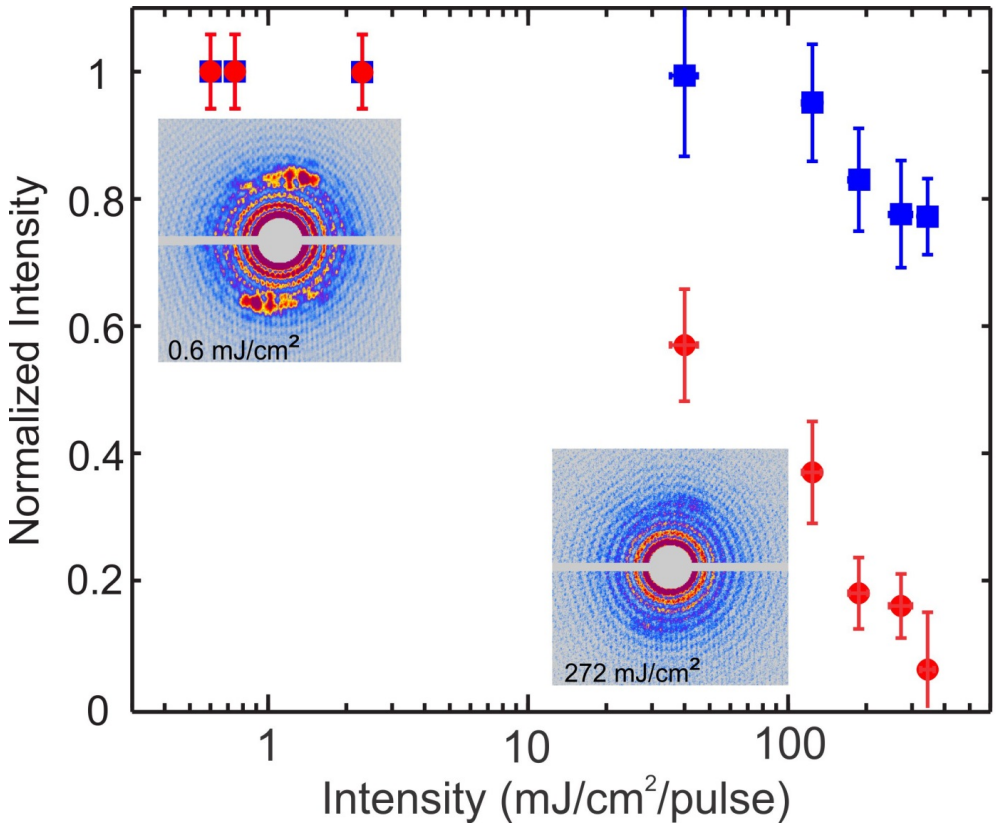
B. Wu et al, Phys.Rev. Lett. **117**, 027401 (2016)

Diffraction patterns disappear at very high x-ray fluence



What is going on?

A fundamental non-linear x-ray effect

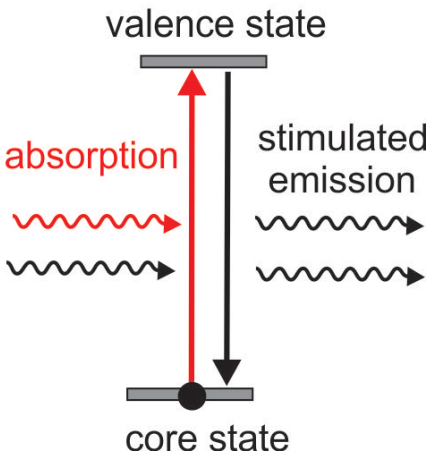


Airy ring intensity

Magnetic contrast

explains resonant magnetic scattering

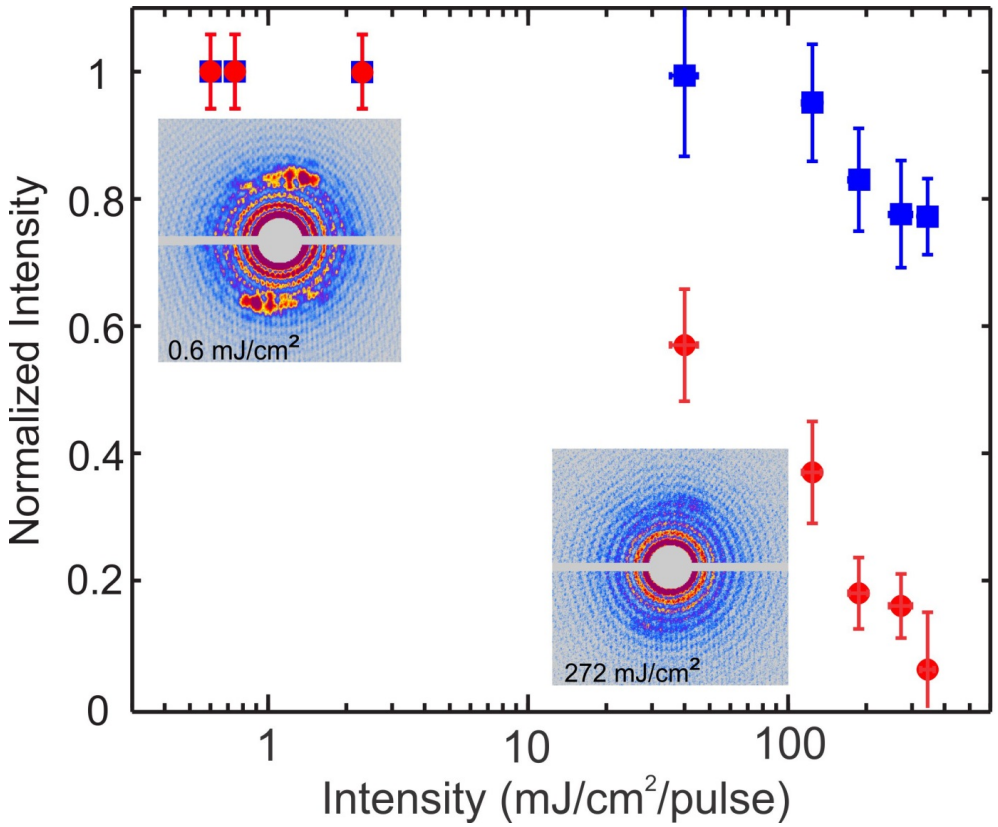
Stimulated resonant scattering



Stöhr and Scherz PRL **115**, 107402 (2015)

B. Wu et al, Phys.Rev. Lett. **117**, 027401 (2016)

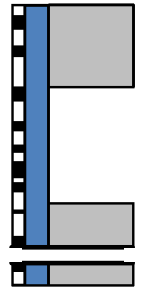
A fundamental non-linear x-ray effect



Airy ring intensity

Magnetic contrast

something else must be going on!



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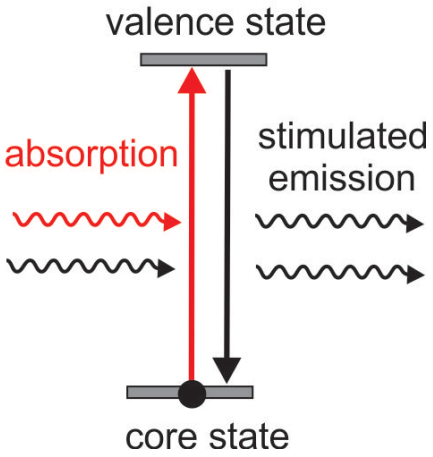

Stöhr and Scherz PRL **115**, 107402 (2015)

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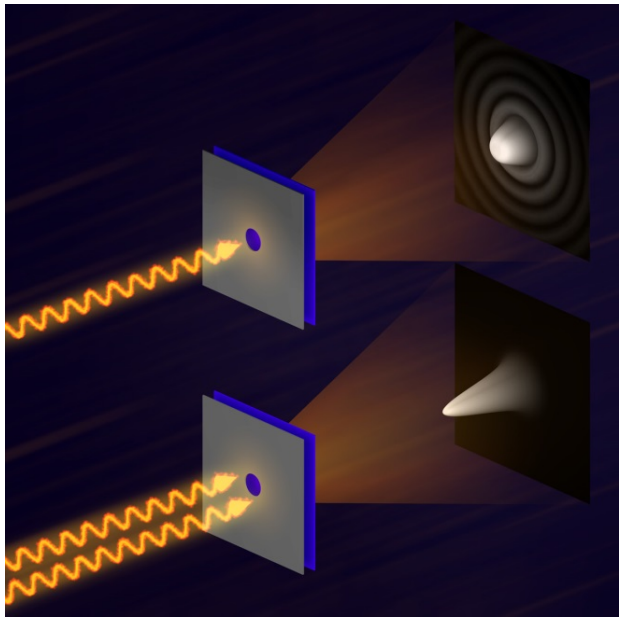
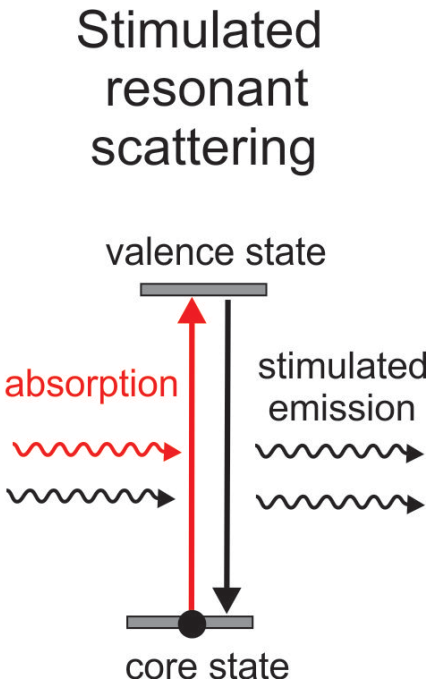
Outlook: Scattering with correlated x-rays

photons cloned by stimulated scattering are ‘correlated’ and behave differently than single photons





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